HIGH PRECISION

COMMANDS AND LOGS

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# UM981

## BDS/GPS/GLONASS/Galileo/QZSS

## All-constellation Multi-frequency

## RTK/INS Integrated Positioning Module

# Revision History

| Version | Revision History | Date |
|---|---|---|
| R1.0 | First release | Sept. 2023 |

## Legal Right Notice



## Disclaimer

Should you purchase our product and encounter any inconsistency, please contact us or our local authorized distributor for the most up-to-date version of this manual along with any addenda or corrigenda.

# Contents

# 1 CONFIG Command

## 1.1 Enable/Disable INS

The INS function of UM981 is enabled by default. Users can input the command CONFIG INS DISABLE to disable INS. If INS needs to be enabled again, use the command CONFIG INS RESET to enable INS and reset INS to the unaligned state.

**Command Format:**

CONFIG INS [parameter]

**Example:**

CONFIG INS DISABLE

**Table 1-1 Enable/Disable INS**

| Log Header | Function | Parameter | Description |
|---|---|---|---|
| CONFIG | INS | Disable | Disable INS |
| | | Reset | Enable INS and reset INS to the unaligned state |

## 1.2 Configure INS Installation Angle

This command is used to set the installation angle of the UM981 module. Make sure that the direction of the XYZ axis of the UM981 module is consistent with that of the vehicle.

**Command Format:**

CONFIG INS ANGLE [parameter]

**Example:**

CONFIG INS ANGLE 0 9000 18000

**Table 1-2 Configure INS Installation Angle**

| Log Header | Function | Field | Parameter | Description |
|---|---|---|---|---|
| CONFIG | INS | ANGLE | ANGLEX | Rotation angle of the X-axis of the UM981 module relative to the X-axis of the vehicle (right-handed), in units of 0.01 degrees, range: 0~36000 |
| | | | ANGLEY | Rotation angle of the Y-axis of the UM981 module relative to the Y-axis of the vehicle (right-handed), in units of 0.01 degrees, range: 0~36000 |
| | | | ANGELZ | Rotation angle of the Z-axis of the UM981 module relative to the Z-axis of the vehicle (right-handed), in units of 0.01 degrees, range: 0~36000 |

## 1.3 Configure INS Timeout

This command is used to set the output duration of INS when losing GNSS signals, in seconds.

**Command Format:**

CONFIG INS TIMEOUT [parameter]

**Example:**

CONFIG INS TIMEOUT 60

**Table 1-3 Configure INS Timeout**

| Log Header | Function | Field | Parameter | Description |
|---|---|---|---|---|
| CONFIG | INS | TIMEOUT | 1~1000 | The maximum time of INS positioning after losing GNSS signals, in seconds |
| | | | > 1000 | Not recommended |

## 1.4 Configure INS Alignment Velocity Threshold

This command is used to set the velocity threshold for INS alignment. If the velocity is lower than the threshold, the INS alignment initialization will not be triggered. When the receiver connects dual antennas and completes heading, the INS will use the heading information to perform alignment and this command is invalid.

**Command Format:**

CONFIG INS ALIGNMENTVEL [parameter]

**Example:**

CONFIG INS ALIGNMENTVEL 5.0

**Table 1-4 Configure INS Alignment Velocity Threshold**

| Log Header | Function | Field | Parameter | Description |
|---|---|---|---|---|
| CONFIG | INS | ALIGNMENTVEL | Velocity threshold | Set the velocity threshold for INS alignment, in meters/second |

## 1.5 Configure Lever Arm between IMU & Master Antenna

This command is used to input the offset between the IMU and the phase center of the GNSS master antenna, which is the lever arm distance. X, Y, and Z represent the vector from the IMU to the phase center of the master antenna. Fields a, b, and c are used to input any possible errors in the measurement. For example, if the accuracy of "X" offset is 1 centimeter, enter 0.01 in the "a" field.

In order to improve the quality of integrated positioning results, the lever arm parameters should be measured as accurate as possible.

**Command Format:**

CONFIG IMUTOANT OFFSET x y z [a] [b] [c]

**Example:**

CONFIG IMUTOANT OFFSET 0.54 0.32 1.20 0.03 0.03 0.05

**Table 1-5 Configure Lever Arm between IMU & Master Antenna**

| Log Header | Parameter | Description |
|---|---|---|
| CONFIG IMUTOANT OFFSET | x | X-axis offset, unit: meter, range: -100~100 |
| | y | Y-axis offset, unit: meter, range: -100~100 |
| | z | Z-axis offset, unit: meter, range: -100~100 |
| | a | Error of the X-axis offset, unit: meter, range: 0.01~10 (default: from 0.01 m to 10% of the X-axis offset) |
| | b | Error of the Y-axis offset, unit: meter, range: 0.01~10 (default: from 0.01 m to 10% of the Y-axis offset) |
| | c | Error of the Z-axis offset, unit: meter, range: 0.01~10 (default: from 0.01 m to 10% of the Z-axis offset) |

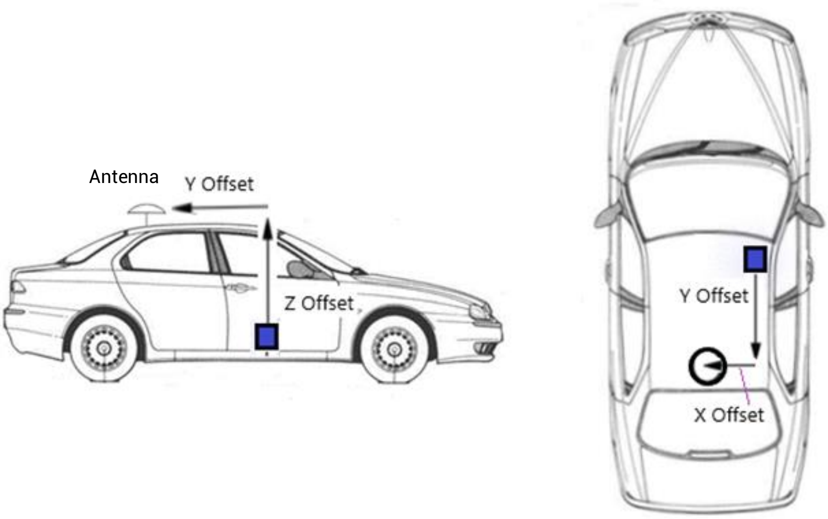


**Figure 1-1 Offset from IMU to the Antenna Phase Center**

When installing the IMU as shown in Figure 1-1, the offset is -X, -Y, and +Z.

# 1.6 Configure INS Position Offset

Assuming the center of the module is O and the other point is P, this command is used to set the value of the vector from O to P, so that messages such as INSPVAX and DRPVA can output the position and velocity at the point P.

**Command Format:**

CONFIG INSSOL OFFSET xoffset yoffset zoffset

**Example:**

CONFIG INSSOL OFFSET 0.15 0.15 0.25

**Table 1-6 Configure INS Position Offset**

| Log Header | Parameter | Description |
|---|---|---|
| CONFIG INSSOL OFFSET | X offset | X-axis offset, unit: meter, range: -100~100 |
| | Y offset | Y-axis offset, unit: meter, range: -100~100 |
| | Z offset | Z-axis offset, unit: meter, range: -100~100 |

## 1.7 Configure INS Initial Azimuth and STD

This command is used to set the initial azimuth and its standard deviation so that INS can finish alignment in static state. In this condition, the accuracy of INS alignment is not high, and it will gradually converge and improve after the vehicle moves for a period of time.

☞ This command cannot be saved.

**Command Format:**

CONFIG INS AZIMUTH azimuth azSTD

**Example:**

CONFIG INS AZIMUTH 90 5

In the above example, the initial azimuth is set to 90 degrees, which means the Y axis points east, within a standard deviation of 5 degrees.

**Table 1-7 Configure INS Initial Azimuth and STD**

| Log Header | Parameter | Description |
|---|---|---|
| CONFIG INS AZIMUTH | azimuth | Initial azimuth, unit: degree, range: 0 ~ 360 (north by east is positive) |
| | azSTD | Standard deviation of azimuth, unit: degree, range: 0.000278 ~ 45 (0.000278 degrees are about one arcsecond), accurate to 6 decimal places |

## 1.8 Configure INS Initial Attitude and STD

This command is used to set the initial attitude and its standard deviation. When using this command, INS can be aligned immediately without the need of dynamic alignment, but the accuracy in this condition is not high, and after the vehicle moves for a period of time, the accuracy of INS will gradually converge and improve.

Notes:

1. The alignment is based on user's real-time input. Using this command will make the system start faster and quickly enter the navigation mode. The input values must be accurate, otherwise the system performance will be affected.

2. If you are not sure about the input attitude, please increase the STD values.

☞ This command cannot be saved.

**Command Format:**

CONFIG INS ATTITUDE pitch roll azimuth pitchSTD rollSTD azSTD

**Example:**

CONFIG INS ATTITUDE 0 0 90 5 5 5

In the above example, the initial pitch and roll are set to 0 degrees, and the initial azimuth is set to 90 degrees, within a standard deviation of 5 degrees. This means that the module is basically mounted horizontally with the Y axis pointing east, within a standard deviation of 5 degrees.

**Table 1-8 Configure INS Initial Attitude and STD**

| Log Header | Parameter | Description |
|---|---|---|
| CONFIG INS ATTITUDE | pitch | INS initial pitch, unit: degree, range: -90 ~ 90 (about X-axis rotation, right-handed) |
| | roll | INS initial roll, unit: degree, range: -90 ~ 90 (about Y-axis rotation, right-handed) |
| | azimuth | INS initial azimuth, unit: degree, range: 0~360 (north by east is positive) |
| | pitchSTD | Standard deviation of pitch, unit: degree, range: 0.000278 ~ 45 (0.000278 degrees are about one arcsecond), accurate to 6 decimal places |

| Log Header | Parameter | Description |
| --- | --- | --- |
| | rollSTD | Standard deviation of roll, unit: degree, range: 0.000278 ~ 45 (0.000278 degrees are about one arcsecond), accurate to 6 decimal places |
| | azSTD | Standard deviation of azimuth, unit: degree, range: 0.000278 ~ 45 (0.000278 degrees are about one arcsecond), accurate to 6 decimal places |

## 1.9 Configure the Vehicle Moving Direction

This command is used to set the initial moving direction of the vehicle to assist INS with dynamic alignment.

**Command Format:**

CONFIG INSDIRECTION [parameter]

**Example:**

CONFIG INSDIRECTION AUTO

CONFIG INSDIRECTION FORWARD

CONFIG INSDIRECTION BACKWARD

**Table 1-9 Configure the Vehicle Moving Direction**

| Log Header | Parameter | Description |
| --- | --- | --- |
| CONFIG INSDIRECTION | AUTO (default) | Automatically detect the moving direction; if the detection fails, it assumes that the vehicle is moving forward. |
| | FORWARD | Moving forward |
| | BACKWARD | Moving backward |

# 2 Data Output

## 2.1 NORMAL Header

Table 2-1 Binary Header Structure

| ID | Field Name | Field Type | Description | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | Sync | Char | Hexadecimal 0xAA. | 1 | 0 |
| 2 | Sync | Char | Hexadecimal 0x44. | 1 | 1 |
| 3 | Sync | Char | Hexadecimal 0x12. | 1 | 2 |
| 4 | Header Length | Uchar | Length of the header 0x1C | 1 | 3 |
| 5 | Message ID | Ushort | Message ID of the log | 2 | 4 |
| 6 | Message Type | Char | 00 = Binary<br>01 = ASCII<br>10 = Abbreviated ASCII | 1 | 6 |
| 7 | Reserved | Uchar | Reserved | 1 | 7 |
| 8 | Message Length | Ushort | The length of the message, in bytes, not including the header nor the CRC | 2 | 8 |
| 9 | Reserved | Ushort | Reserved | 2 | 10 |
| 10 | Idle Time | Uchar | CPU idle, 0~100 | 1 | 12 |
| 11 | Time Status | Enum | The quality of the GPS reference time.<br>20 = UNKNOWN; 160 = FINE | 1 | 13 |
| 12 | Week | Ushort | GPS reference week number | 2 | 14 |

| ID | Field Name | Field Type | Description | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 13 | ms | Ulong | Milliseconds from the beginning of the GPS reference week | 4 | 16 |
| 14 | Reserved | Ulong | | 4 | 20 |
| 15 | BDS time offset to GPS Second | Ushort | Time offset between BDS and GPS.<br>This field stores the time offset between BDS second and GPS second within a week.<br>BDS second = GPS second – offset | 2 | 24 |
| 16 | Reserved | Ushort | | 2 | 26 |

**Table 2-2 ASCII Header Structure**

| ID | Field Name | Field Type | Description |
|---|---|---|---|
| 1 | Sync | Char | Sync character. The ASCII message is always preceded by a "#" symbol |
| 2 | Message | Char | The ASCII name of the log or command |
| 3 | Port | Char | The name of the port from which the log was generated. The string is made up of the port name followed by an _x where x is a number from 1 to 31 denoting the virtual address of the port. If no virtual address is indicated, it is assumed to be address 0. |
| 4 | Sequence# | Long | Used for multiple related logs. It is a number that counts down from N-1 to 0, where 0 means it is the last one of the set. Most logs only come out one at a time in which case this number is 0 |

| ID | Field Name | Field Type | Description |
|---|---|---|---|
| 5 | % IdleTime | Float | The minimum percentage of time the processor is idle, calculated once per second |
| 6 | TimeStatus | Enum | The quality of the GPS reference time.<br>Value = Unknown or Fine, Unknown means the receiver hasn't calculated the accurate GPS time. |
| 7 | Week | Ulong | GPS reference week number |
| 8 | Seconds | GPSec | Seconds from the beginning of the GPS reference week; accurate to the millisecond level |
| 9 | Receiver Status | Ulong | Reserved |
| 10 | BDS time offset to GPS Second | Char | Reserved |
| 11 | UTC time offset to GPS Second | Ulong | Current leap seconds |
| 12 | ; | Char | The character indicates the end of the header |

## 2.2 SHORT Header

The total length of the BINARY header is 12 bytes.

**Table 2-3 Short Header in Binary Format**

| ID | Field Name | Field Type | Description | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | Sync | Uchar | Hexadecimal 0xAA. | 1 | 0 |
| 2 | Sync | Uchar | Hexadecimal 0x44. | 1 | 1 |
| 3 | Sync | Uchar | Hexadecimal 0xB6 | 1 | 2 |

| ID | Field Name | Field Type | Description | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 4 | MessageLength | Uchar | Message length, not including the header | 1 | 3 |
| 5 | Message ID | Ushort | Message ID | 2 | 4 |
| 6 | Wn | Ushort | GPS reference week number | 2 | 6 |
| 7 | Ms | ULONG | Milliseconds from the beginning of the GPS reference week | 4 | 8 |

**Table 2-4 Short Header in ASCII Format**

| ID | Field Name | Field Type | Description |
|---|---|---|---|
| 1 | Sync | Char | Sync character. The ASCII message is always preceded by a single "%" symbol |
| 2 | Message | Char | The ASCII name of the log or command |
| 3 | Wn | Ushort | GPS reference week number |
| 4 | Ms | ulong | Milliseconds from the beginning of the GPS reference week |

## 2.3 Data Output

A log consists of a header, data and CRC.

Header has two formats—normal header and short header. For detailed information, please see the previous section.

For each message, there are 4 output formats at most.

1) XXXA represents normal header in ASCII format;
2) XXXB represents normal header in BINARY format;
3) XXXSA represents short header in ASCII format;
4) XXXSB represents short header in BINARY format;

Taking GYRATT message for example, the 4 output formats are shown below.

**Table 2-5 Data Output Formats**

| | Normal header | Short header |
|---|---|---|
| ASCII | GYRATTA | GYRATTSA |
| BINARY | GYRATTB | GYRATTSB |

* So far, only GYRATT supports SHORT header.

### 2.3.1 IMUATT

After the INS initialization is finished, this log outputs IMU measurements and INS attitude information.

**Message ID: 1442**

**ASCII Syntax:**

IMUATTA 0.1

**BINARY Syntax:**

IMUATTB 0.1

**Message Output:**

#IMUATTA,87,GPS,FINE,2264,459002400,0,0,18,10404;INS_ALIGNING,NONE,0,0,0,0,0,-31,-166,-3974,-5,-1,2,0,0*bf075814

**Table 2-6 IMUATT Message Structure**

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | IMUATT header | Log header, see Table 2-1 Binary Header Structure and Table 2-2 ASCII Header Structure | | H | 0 |
| 2 | INS Status | INS solution status, see Table 2-7 | Enum | 4 | H |
| 3 | Pos Type | Position type, see Table 2-8 | Enum | 4 | H+4 |
| 4 | SOL age | INS solution age, in units of 0.001 s | UINT | 4 | H+8 |
| 5 | Dr age | INS DR age, in units of 0.1 s | USHORT | 2 | H+12 |
| 6 | Roll | Roll (right-handed rotation around Y axis), unit: 360/32767 [deg] | SHORT | 2 | H+14 |

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 7 | Pitch | Pitch (right-handed rotation around X axis), unit: 360/32767 [deg] | SHORT | 2 | H+16 |
| 8 | Azimuth | Azimuth, north by east is positive, unit: 360/32767 [deg] | SHORT | 2 | H+18 |
| 9 | Acc_X | Acceleration along X axis, unit: 80/32767[m/s^2] | SHORT | 2 | H+20 |
| 10 | Acc_Y | Acceleration along Y axis, unit: 80/32767[m/s^2] | SHORT | 2 | H+22 |
| 11 | Acc_Z | Acceleration along Z axis, unit: 80/32767[m/s^2] | SHORT | 2 | H+24 |
| 12 | Gyro_X | Angular velocity around X axis, unit: 500/32767[deg/s] | SHORT | 2 | H+26 |
| 13 | Gyro_Y | Angular velocity around Y axis, unit: 500/32767[deg/s] | SHORT | 2 | H+28 |
| 14 | Gyro_Z | Angular velocity around Z axis, unit: 500/32767[deg/s] | SHORT | 2 | H+30 |
| 15 | Reserved | Reserved | SHORT | 2 | H+32 |
| 16 | Reserved | Reserved | SHORT | 2 | H+34 |
| 17 | xxxx | 32-bit CRC (ASCII or binary) | Hex | 4 | H+36 |
| 18 | [CR][LF] | Sentence terminator (ASCII only) | - | | |

**Table 2-7 INS Solution Status**

| Binary | Field | Description |
|---|---|---|
| 0 | INS_INACTIVE | IMU data invalid; INS inactive |
| 1 | INS_ALIGNING | INS is aligning |
| 2 | INS_HIGH_VARIANCE | INS is in navigation mode, but the error of azimuth has exceeded the threshold. For most IMUs, the default threshold is 2 degrees. |

| Binary | Field | Description |
|---|---|---|
| 3 | INS_SOLUTION_GOOD | Entered the navigation mode and the INS solution is good |
| 6 | INS_SOLUTION_FREE | DR mode, no GNSS participated in the integrated solution |
| 7 | INS_ALIGNMENT_COMPLETE | INS alignment completed, but not enough vehicle dynamics to make the accuracy meet the requirement. |

**Table 2-8 Position and Velocity Type**

| Binary | Field | Description |
|---|---|---|
| 0 | NONE | No solution |
| 1-51 | Reserved | Reserved |
| 52 | INS | Only inertial navigation solution |
| 53 | INS_PSRSP | Integrated solution of INS and single point positioning |
| 54 | INS_PSRDIFF | Integrated solution of INS and pseudorange differential positioning |
| 55 | INS_RTKFLOAT | Integrated solution of INS and RTK float |
| 56 | INS_RTKFIXED | Integrated solution of INS and RTK fix |
| 57-74 | Reserved | Reserved |

## 2.3.2 GYRATT

After the INS initialization is finished, this log outputs IMU measurements and INS attitude information.

**Message ID:**

GYRATT: 1444
GYRATTS: 1443

**ASCII Syntax:**

GYRATTA 0.1
GYRATTSA 0.1

**BINARY Syntax:**

GYRATTB 0.1

GYRATTSB 0.1

**Message Output:**

#GYRATTA,86,GPS,FINE,2264,458998000,0,0,18,6003;INS_ALIGNING,NONE,0,0,0,0,0,0,0,0
*d027dc6b

%GYRATTSA,2264,459017550;INS_ALIGNING,NONE,0,0,0,0,0,0,0,0*89b0a7b9

**Table 2-9 GYRATT Message Structure**

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | GYRATT header | Log header, see Table 2-1, Table 2-2, Table 2-3 and Table 2-4 | | H | 0 |
| 2 | INS Status | INS solution status, see Table 2-7 | UCHAR | 1 | H |
| 3 | Pos Type | Position type, see Table 2-8 | UCHAR | 1 | H+1 |
| 4 | Dr age | INS DR age, in units of 0.1 s | USHORT | 2 | H+2 |
| 5 | SOL age | INS solution age, in units of 0.001 s | UINT | 4 | H+4 |
| 6 | Roll | Roll (right-handed rotation around the Y axis), unit: 360/32767 [deg] | SHORT | 2 | H+8 |
| 7 | Pitch | Pitch (right-handed rotation around the X axis), unit: 360/32767 [deg] | SHORT | 2 | H+10 |
| 8 | Azimuth | Azimuth, north by east is positive, unit: 360/32767 [deg] | SHORT | 2 | H+12 |
| 9 | Gyro_Z | Angular velocity around Z axis, unit: 500/32767 [deg/s] | SHORT | 2 | H+14 |
| 10 | Reserved | Reserved | SHORT | 2 | H+16 |
| 11 | Reserved | Reserved | SHORT | 2 | H+18 |
| 12 | xxxx | 32-bit CRC (ASCII or binary) | Hex | 4 | H+20 |
| 13 | [CR][LF] | Sentence terminator (ASCII only) | - | | |

### 2.3.3 INSHOTINFOR0

After the board starts up, this message is output to the host computer. At the next time the board is powered on, the host computer will transmit the previously received message to the board to assist in the quick initialization of INS.

**Message ID: 1441**

**BINARY Syntax:**

INSHOTINFOR0B 0.1

**Table 2-10 INSHOTINFOR0 Message Structure**

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | INSHOTINFOR0 header | Log header, see Table 2-1 Binary Header Structure and Table 2-2 ASCII Header Structure | | H | 0 |
| 2~15 | Body[48] | Data | Char | 48 | H |
| 16 | xxxx | 32-bit CRC (ASCII or binary) | Hex | 4 | H+48 |
| 17 | [CR][LF] | Sentence terminator (ASCII only) | - | | |

## 2.3.4 INSPVAX

This log is used to output the integrated position, velocity, attitude, and their estimated errors.

**Message ID: 1465**

**ASCII Syntax:**

INSPVAXA 1

**BINARY Syntax:**

INSPVAXB 1

**Message Output:**

#INSPVAXA,COM1,0,73.5,FINESTEERING,1695,309428.000,00000040,4e77,43562;
INS_SOLUTION_GOOD,INS_PSRSP,51.11637873403,-114.03825114994,1063.6093,-
16.9000,-0.0845,-0.0464,-0.0127,0.138023492,0.069459386,90.000923268,0.9428,
0.6688,1.4746,0.0430,0.0518,0.0521,0.944295466,0.944567084,1.000131845,3,0*e877c
178

Table 2-11 INSPVAX Message Structure

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | INSPVAX | Log header, see Table 2-1 Binary Header Structure and Table 2-2 ASCII Header Structure | | H | 0 |
| 2 | INS Status | INS status, see Table 2-7 INS Solution Status | Enum | 4 | H |
| 3 | Pos Type | Position type, see Table 2-8 Position and Velocity Type | Enum | 4 | H+4 |
| 4 | Latitude | Latitude (WGS84) [degrees] | Double | 8 | H+8 |
| 5 | Longitude | Longitude (WGS84) [degrees] | Double | 8 | H+16 |
| 6 | Height | Height [m] | Double | 8 | H+24 |
| 7 | Undulation | Geoidal separation – the difference between the mean-sea-level (geoid) surface and the WGS84 ellipsoid surface, in meters. If the geoid is above the ellipsoid, the value is positive; otherwise, it is negative. | Float | 4 | H+32 |
| 8 | North Velocity | Velocity in a northerly direction (negative implies south) [m/s] | Double | 8 | H+36 |
| 9 | East Velocity | Velocity in an easterly direction (negative implies west) [m/s] | Double | 8 | H+44 |
| 10 | Up Velocity | Velocity in an up direction [m/s] | Double | 8 | H+52 |
| 11 | Roll | Roll (right-handed rotation around Y axis) [degrees] | Double | 8 | H+60 |
| 12 | Pitch | Pitch (right-handed rotation around X axis) [degrees] | Double | 8 | H+68 |
| 13 | Azimuth | Azimuth, clockwise from north (left-handed rotation around Z axis) [degree]. This is the inertial azimuth calculated from the IMU gyros and integrated filters. | Double | 8 | H+76 |

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 14 | Lat σ | Standard deviation of latitude [m] | Float | 4 | H+84 |
| 15 | Long σ | Standard deviation of longitude [m] | Float | 4 | H+88 |
| 16 | Height σ | Standard deviation of height [m] | Float | 4 | H+92 |
| 17 | North Vel σ | Standard deviation of north velocity [m/s] | Float | 4 | H+96 |
| 18 | East Vel σ | Standard deviation of east velocity [m/s] | Float | 4 | H+100 |
| 19 | Up Vel σ | Standard deviation of up velocity [m/s] | Float | 4 | H+104 |
| 20 | Roll σ | Standard deviation of roll [degrees] | Float | 4 | H+108 |
| 21 | Pitch σ | Standard deviation of pitch [degrees] | Float | 4 | H+112 |
| 22 | Azimuth σ | Standard deviation of azimuth [degrees] | Float | 4 | H+116 |
| 23 | Ext sol stat | Extended solution status, see Table 2-12 Extended Solution Status | Hex | 4 | H+120 |
| 24 | Time Since Update | Time elapsed since the last ZUPT or position update (seconds) | Ushort | 2 | H+124 |
| 25 | xxxx | 32-bit CRC | Hex | 4 | H+126 |
| 26 | [CR][LF] | Sentence terminator (ASCII only) | - | - | - |

**Table 2-12 Extended Solution Status**

| Bit | Mask (Hexadecimal) | Description |
|---|---|---|
| 0 | 0x00000001 | Position update |
| 1 | 0x00000002 | Phase update |
| 2 | 0x00000004 | Zero velocity update |
| 3 | 0x00000008 | Wheel sensor update |
| 4 | 0x00000010 | ALIGN (heading) update |
| 5 | 0x00000020 | Reserved |
| 6 | 0x00000040 | INS solution convergence flag |

| Bit | Mask (Hexadecimal) | Description |
|---|---|---|
| 7 | 0x00000080 - 0x80000000 | Reserved |

### 2.3.5 RAWIMUX

This log contains IMU status, accelerometer and gyro measurements in the coordinate system marked on the IMU enclosure. It is output on time and the output frequency can be configured up to 100Hz. This log supports ASCII format and binary format.

**Message ID: 1461**

**ASCII Syntax:**

RAWIMUXA 0.01

**BINARY Syntax:**

RAWIMUXB 0.01

**Message Output:**

#RAWIMUXA,COM1,0,60.0,FINE,2261,366772.050,0,0,0;00,64,2261,366772.050,0ac00000,16278,-70,172,-1044,-90,-200*bffb7522

**Table 2-13 RAWIMUX Message Structure**

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | RAWIMUX header | Log header, see Table 2-1 Binary Header Structure and Table 2-2 ASCII Header Structure | - | H | 0 |
| 2 | IMU error | Abbreviated IMU erroneous flag<br>01 – IMU erroneous<br>00 – IMU normal | Uchar | 1 | H |
| 3 | IMU type | IMU status, see Table 2-14 | Uchar | 1 | H+1 |
| 4 | Week | GNSS week | Ushort | 2 | H+2 |
| 5 | Seconds Into Week | Seconds from the start of the week | Double | 8 | H+4 |
| 6 | IMU Status | IMU status, see Table 2-15 | Hex Ulong | 4 | H+12 |

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 7 | Z Accel Output | Accelerometer measurement along Z axis. See Table 2-14 IMU Type | Long | 4 | H+16 |
| 8 | - (Y Accel Output) | Accelerometer measurement along (-Y) axis. See Table 2-14 IMU Type | Long | 4 | H+20 |
| 9 | X Accel Output | Accelerometer measurement along X axis. See Table 2-14 IMU Type | Long | 4 | H+24 |
| 10 | Z Gyro Output | Gyro measurement along Z axis. See Table 2-14 IMU Type | Long | 4 | H+28 |
| 11 | - (Y Gyro Output) | Gyro measurement along (-Y) axis. See Table 2-14 IMU Type | Long | 4 | H+32 |
| 12 | X Gyro Output | Gyro measurement along X axis. See Table 2-14 IMU Type | Long | 4 | H+36 |
| 13 | xxxx | 32-bit CRC | Hex | 4 | H+40 |
| 14 | [CR][LF] | Sentence terminator (ASCII only) | - | - | - |

**Table 2-14 IMU Type**

| ID | IMU | Gyro Scale Factor | Accelerometer Scale Factor |
|---|---|---|---|
| 0 | UNKNOWN | | |
| 64 | 02 | 250/32767 (deg/s) | 2g/32767 |

**Table 2-15 02 IMU Status**

<table>
<tr><th>Nibble</th><th>Bit</th><th>Mask</th><th>Description</th><th>Range Value</th></tr>
<tr><td rowspan="4">N0</td><td>0</td><td>0x00000001</td><td>Alarm Status Flag</td><td></td></tr>
<tr><td>1</td><td>0x00000002</td><td rowspan="2" colspan="2">Reserved</td></tr>
<tr><td>2</td><td>0x00000004</td></tr>
<tr><td>3</td><td>0x00000008</td><td>SPI Communication Error</td><td>0 = Passed, 1 = Failed</td></tr>
<tr><td>N1</td><td>4</td><td>0x00000010</td><td>Sensor Over-Range</td><td>0 = Passed,<br>1 = One of more sensors over-ranged</td></tr>
</table>

| Nibble | Bit | Mask | Description | Range Value |
|---|---|---|---|---|
| | 5 | 0x00000020 | Initial Self Test Failure | 0 = Passed, 1= Failed |
| | 6 | 0x00000040 | Flash Memory Failure | 0 = Passed, 1= Failed |
| | 7 | 0x00000080 | Processing Overrun | 0 = Passed, 1= Failed |
| N2 | 8 | 0x00000100 | Self Test Failure – X-axis gyro | 0 = Passed, 1= Failed |
| | 9 | 0x00000200 | Self Test Failure – Y-axis gyro | 0 = Passed, 1= Failed |
| | 10 | 0x00000400 | Self Test Failure – Z-axis gyro | 0 = Passed, 1= Failed |
| | 11 | 0x00000800 | Self Test Failure – X-axis accelerometer | 0 = Passed, 1= Failed |
| N3 | 12 | 0x00001000 | Self Test Failure – Y-axis accelerometer | 0 = Passed, 1= Failed |
| | 13 | 0x00002000 | Self Test Failure – Z-axis accelerometer | 0 = Passed, 1= Failed |
| | 14 | 0x00004000 | Reserved | |
| | 15 | 0x00008000 | | |
| N4 | 16 | 0x00010000 | The temperature information is stored in an 11-bit data (two's complement) from bit 21 to bit 31, and the conversion algorithm to floating point temperature (°C) is as follows:<br><br>ULONG ulStatus;<br>SHORT sTemp = INT(ulStatus) >>21;<br>FLOAT fTemperature = sTemp*0.125+23; | |
| | 17 | 0x00020000 | | |
| | 18 | 0x00040000 | | |
| | 19 | 0x00080000 | | |
| N5 | 20 | 0x00100000 | | |
| | 21 | 0x00200000 | | |
| | 22 | 0x00400000 | | |
| | 23 | 0x00800000 | | |
| N6 | 24 | 0x01000000 | | |
| | 25 | 0x02000000 | | |
| | 26 | 0x04000000 | | |
| | 27 | 0x08000000 | | |

| Nibble | Bit | Mask | Description | Range Value |
|---|---|---|---|---|
| N7 | 28 | 0x10000000 | | |
| | 29 | 0x20000000 | | |
| | 30 | 0x40000000 | | |
| | 31 | 0x80000000 | | |

### 2.3.6 DRPVA

This log is used to output GNSS+INS integrated position, velocity, attitude, and their standard deviations.

**Message ID: 57024**

**ASCII Syntax:**

DRPVAA 0.2

**BINARY Syntax:**

DRPVAB 0.2

**Message Output:**

#DRPVAA,COM1,0,92.0,FINE,1867,111471.800,00000000,14,0;SOL_COMPUTED,SINGLE,
WGS84,0,0,0,0,0.800,2573.000,40.07899836523,116.23661722090,68.5569,-
9.7848,0.1522,0.1489,0.0213,-0.0001,-
0.0001,0.0010,0.0096,0.0097,0.0097,359.589710,-
1.236787,1.344697,0.0000,0.0020,0.0020,1,0,0,0,0.0000,0.0000,0.0000,0.0000,0.000000,
0.000000,0.000000,0.000000*9aa8b508

**Table 2-16 DRPVA Message Structure**

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 1 | DRPVA header | Log header, see Table 2-1 Binary Header Structure and Table 2-2 ASCII Header Structure | | H | 0 |
| 2 | sol status | Solution status, see Table 2-17 | Enum | 4 | H |
| 3 | pos type | Position type, see Table 2-8 | Enum | 4 | H+4 |
| 4 | datum id# | Datum ID, only WGS84 (binary = 61) is supported currently | Enum | 4 | H+8 |

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 5~8 | Reserved[4] | Reserved | CHAR | 4 | H+12 |
| 9 | Dr_age | Age of DR only, seconds | Float | 4 | H+16 |
| 10 | Sol_age | Age of continuous positioning, seconds | Float | 4 | H+20 |
| 11 | lat | Latitude, degrees | Double | 8 | H+24 |
| 12 | lon | Longitude, degrees | Double | 8 | H+32 |
| 13 | hgt | Height, meters | Double | 8 | H+40 |
| 14 | undulation | Geoidal separation – the difference between the mean-sea-level (geoid) surface and the WGS84 ellipsoid surface, in meters. | Float | 4 | H+48 |
| 15 | lat σ | Standard deviation of latitude, meters | Float | 4 | H+52 |
| 16 | lon σ | Standard deviation of longitude, meters | Float | 4 | H+56 |
| 17 | hgt σ | Standard deviation of height, meters | Float | 4 | H+60 |
| 18 | Ve | Velocity in an easterly direction, m/s | Double | 8 | H+64 |
| 19 | Vn | Velocity in a northerly direction, m/s | Double | 8 | H+72 |
| 20 | Vu | Velocity in an up direction, m/s | Double | 8 | H+80 |
| 21 | Veσ | Standard deviation of east velocity, m/s | Float | 4 | H+88 |
| 22 | Vnσ | Standard deviation of north velocity, m/s | Float | 4 | H+92 |
| 23 | Vuσ | Standard deviation of up velocity, m/s | Float | 4 | H+96 |

| ID | Field Type | Data Description | Format | Binary Bytes | Binary Offset |
|---|---|---|---|---|---|
| 24 | Heading | Heading, north by east is positive, degrees, [0,360] | Double | 8 | H+100 |
| 25 | Pitch | Pitch, the vehicle heading up is positive, in degrees, [-90, 90] | Double | 8 | H+108 |
| 26 | Roll | Roll, the vehicle body leaning right is positive, in degrees, [-180, 180] | Double | 8 | H+116 |
| 27 | Heading σ | Standard deviation of heading, degrees | Float | 4 | H+124 |
| 28 | Pitch σ | Standard deviation of pitch, degrees | Float | 4 | H+128 |
| 29 | Roll σ | Standard deviation of roll, degrees | Float | 4 | H+132 |
| 30~33 | Reserved[4] | Reserved | Long | 16 | H+136 |
| 34~37 | Reserved[4] | Reserved | Float | 16 | H+152 |
| 38~41 | Reserved[4] | Reserved | Double | 32 | H+168 |
| 42 | xxxx | 32-bit CRC (ASCII and binary) | Hex | 4 | H+200 |
| 43 | [CR][LF] | Sentence terminator (ASCII only) | - | - | - |

**Table 2-17 Solution Status**

| Solution Status | | Description |
|---|---|---|
| 0 | SOL_COMPUTED | Solution computed |
| 1 | INSUFFICIENT_OBS | Insufficient observation |
| 2 | NO_CONVERGENCE | No convergence, invalid solution |
| 4 | COV_TRACE | Covariance matrix trace exceeds maximum (trace > 1000 m) |

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